

**High Resolution Fourier Transform Spectroscopy
of the Vibration-Rotation Spectrum of the OD Radical**

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ABSTRACT

The infrared spectrum of the deuterated hydroxyl radical OD has been measured with a Fourier transform spectrometer between 1850 and 9000 cm^{-1} . The source, a deuterium-atom ozone diffusion flame, was designed to study the chemiluminescent excitation of the vibration-rotation energy levels of the OD radical. Twenty-one bands were observed, six bands in the $\Delta\nu = 1$ sequence, nine bands in the $\Delta\nu = 2$ sequence, and six bands in the $\Delta\nu = 3$ sequence. A global nonlinear least-squares fit, utilizing the unique perturber approximation, of 2112 lines to 76 molecular parameters yielded a standard deviation of 0.007 cm^{-1} including 35 parameters for the previously unobserved $v = 6 - 10$ vibrational states.

I. INTRODUCTION

The hydroxyl radical OH, and the isotopic variants OD and OT have been the subject of considerable spectroscopic investigation over the past several decades due to its excitation in astrophysical, chemical, and physical sources. The vibration-rotation spectrum of OH was first identified in the air-glow of the upper atmosphere by Meinel (1), and interest in the chemiluminescent excitation has continued to the present due to the unusual excitation of many vibrational energy levels. However, prior to the present work, the spectroscopy of the OD radical has not included chemiluminescent excitation, and consequently the vibrational manifold has been studied only up to $v = 5$, the highest state excited in conventional high temperature flames. Coxon (2) determined molecular parameters for the ground electronic state of OD from measurements of the electronic spectrum. Amiot *et al* (3) examined the spectrum of OD produced in a deuterium-oxygen flame and merged their infrared Fourier transform results with earlier microwave and ultraviolet spectroscopy to obtain molecular parameters for the vibrational levels $v = 0 \rightarrow 5$ within the ground electronic state. Brown and Schubert (4) examined the EPR spectrum of the OD radical and obtained molecular parameters for the $v = 0$ level of the ground state. Amano (5) combined difference laser measurements of the OH and OD radicals to obtain the improved parameters for the $v = 0$ and 1 states.

In the present paper the infrared spectrum of OD has been studied in a diffusion reaction of atomic deuterium and ozone at low pressure which approximates the conditions under which the chemiluminescent emission of the nighttime air glow is observed. The distribution of lines among the bands is indicated in Table 1 which summarizes the number of lines in each branch and band. This work complements a similar study of the infrared spectrum of the OH Meinel vibration-rotation bands (Abrams *et al* (6)).

The spectrum lines were subjected to a simultaneous nonlinear least-square fit to determine molecular parameters utilizing the unique perturber approximation. Due to the extensive and near equal coverage of all observed vibrational bands within the ground electronic state and the simultaneity of the measurement of all spectral lines, merging with other data sets was not appropriate, the accuracy and relative precision of the line positions being considerably better than any previous measurement. The extension of the vibration-rotation bands beyond the $v = 5$ energy state provides Hamiltonian parameters and energy levels commensurate with existing analyses of the OH spectrum, and may facilitate

new determinations of Hamiltonian parameters through the combination of the two isotopic forms of the radical.

II. EXPERIMENTAL

A description of the spectrometer and the methods of data transformation and reduction have been presented earlier (7). In brief, the spectrum was measured with the 1 meter Fourier transform spectrometer at the McMath Solar Telescope at the National Solar Observatory, Kitt Peak. The spectrometer is a dual-beam Michelson interferometer utilized in this case with the maximum single-passed unapodized resolution of 0.0096 cm^{-1} . The source of the radicals was a low pressure reaction cell in which gaseous ozone and dissociated deuterium were flowed together at room temperature ($T \leq 300 \text{ K}$) and a pressure of 4 torr. In the upper atmosphere, similar conditions permit the excitation of the vibration-rotation bands of OH which produce the infrared nightglow. The reaction producing the excited radicals is $D + O_3 \rightarrow O_2 + OD^*$, where the very substantial energy of the reaction initially goes mostly into vibrational excitation of the molecule. Due to the relatively cool temperature and low pressure of the reaction cell the emission lines have widths that are typically narrower than the maximum resolution of the spectrometer. Consequently, the lines are noticeable distorted by the instrumental line shape function, a sinc function, and for all lines with signal-to-noise ratios greater than 30 the oscillatory sidelobes of the sinc function are very noticeable.

Although great care was taken to purge the cell of all impurities, 12 emission lines from the $\text{CO}_2 \nu_3$ band were observed in the spectrum and utilized to calibrate the spectrum. Standard reference line positions were taken from the measurements by Guelachvili *et al* (8); a correction factor of 1.000000717 was determined using 12 lines. An estimate of the absolute error may be obtained from the residual error in the process of fitting the lines. Brault (9) has demonstrated that line position error should not exceed $(W/2)(S/N)^{-1}$. The lines have signal-to-noise ratios ranging between 2 and 5000. Hence, a worst case situation would take a line with a width of 10 mK and a signal-to-noise ratio of 2 leading to an error not greater than $\sim 2.5 \text{ mK}$.

III. THEORY

The development of effective Hamiltonians for describing the observed spectra of diatomic molecules has been addressed by several authors. Hougen (10) unified the notation and formalism for diatomics,

Carrington *et al*(11) developed tensor methods for open shell diatomics, Zare *et al*(12) developed the unique perturber approximation, and Brown *et al*(13) developed an effective Hamiltonian using a formal tensor approach. Results from the later two approaches have been previously utilized and compared in the analysis of highly excited states of OD (Abrams *et al*(14)). For the present work the unique perturber method is sufficient.

An effective Hamiltonian for the interpretation of the spectra of diatomic molecules begins with an approximation to the exact Hamiltonian

$$H = H_0 + H_{ROT} + H_{CD} + H_{FS} + H_{LD} + H_{CDLD} \quad (1)$$

where H_0 includes all the rotation independent terms of the Born-Oppenheimer approximation. The hyperfine splitting is unresolved in the infrared and consequently the hyperfine interaction terms have been omitted. H_{ROT} is the rotational energy and H_{CD} includes the centrifugal distortions of the rotational energy. The term H_{FS} describes the fine structure interactions and H_{LD} and H_{CDLD} describe the lambda doubling interaction and its centrifugal distortion.

The nuclear rotational energy operator H_{ROT} can be evaluated using Hund's coupling case (a), where the operator R represents the angular momentum of the rigid nuclear framework

$$H_{ROT} = B(r)R^2 = B(r)[(J - L) - S]^2. \quad (2)$$

The fourth term H_{FS} includes the interactions between the orbital, spin and rotational angular momenta of the electrons

$$H_{FS} = H_{SS} + H_{SO} + H_{SR}. \quad (3)$$

In all ${}^2\Pi$ states the spin-spin interaction energy is rigorously zero. The spin-orbit interaction is

$$H_{SO} = A(r)L \cdot S + \frac{1}{2}A(r)(L_+S_- + L_-S_+) \quad (4)$$

and

$$H_{SR} = \gamma(r)(J - L - S) \cdot S \quad (5)$$

is the spin-rotation interaction energy operator.

In the preceding discussion interactions that couple different electronic states were neglected; however, interactions between Σ and Π states of the same multiplicity produce the lambda doubling splitting which remove the degeneracies of the Λ components of the ${}^2\Pi$ state. A Van Vleck transformation

(15) may be used to combine effects of the perturbing states as a correction to the matrix elements of the Born-Oppenheimer states. The Van Vleck transformation can be used to generate higher-order corrections to account for the centrifugal distortion of the molecule as it rotates. The sextic centrifugal distortion H results from a third-order Van Vleck correction to the rotational energy as does the centrifugal correction to the lambda-doubling parameters which generates the parameters p_D and q_D .

Evaluation of the matrix elements of the unique perturber approximation Hamiltonian utilizes the Hund's coupling case (a) basis set of wavefunctions which are simultaneous eigenstates of J^2 , S^2 , J_Z , S_Z , and L_Z with eigenvalues $J(J + 1)$, $S(S + 1)$, Ω , Σ , and Λ . The total wavefunction is $|n, v\rangle|\Lambda, S, \Sigma; J, M_J, \Omega\rangle$ where $|n, v\rangle$ is the electronic-vibrational wavefunction and $|\Lambda, S, \Sigma; J, M_J, \Omega\rangle$ is the case (a) angular momentum wavefunction. The wavefunctions are symmetrized with respect to reflections in the plane containing the internuclear axis and labeled as e or f levels depending on the parity $(-1)^{J-\frac{1}{2}}$ or $(-1)^{J+\frac{1}{2}}$ respectively for half-integral spin. The Van Vleck transformation reduces the Hamiltonian into a (4×4) secular determinant. If we choose eigenstates of well-defined parity the (2×2) sub-blocks are degenerate without interactions with other Born-Oppenheimer states. The relevant matrix elements for the unique perturber approximation Hamiltonian of a ${}^2\Pi$ state are given in Table 2 and have been used in previous studies of OD (3, 14); they differ from those used by Amiot *et al* (3) only in the presence of a minus sign in the L -type parameters.

IV. RESULTS

The reduction of the spectrum into a linelist was accomplished with the interactive data-processing program DECOMP written by J. W. Brault (16). Initial line positions are determined by derivative filtering with a Voigt kernel after convolution with a three-point Gaussian filter to suppress the sidelobes of the instrumental line shape function. After a visual inspection to verify the plausibility of the list, each line was fitted to a Voigt function. Accurate estimates of the position, strength, full width, and Gaussian/Lorentzian mixture would normally be obtained within a few iterations. The lines are sufficiently narrow that the observed line shape is dominated by the instrumental line shape, a sinc function, rather than a Voigt function for the appropriate pressure and temperature of the source. Suppression of the ringing is possible through apodization. However, the resultant line positions proved to be biased sufficiently to distort the reduction of the line positions into Hamiltonian parameters. A closer examination of the spectra revealed that the apodization necessary to suppress the ringing smeared

many lines together, and in some cases prevented the measurement of individual *e* and *f* components. We developed a method for measuring accurate line positions and shapes in an under-resolved Fourier transform spectrum without compromising the signal-to-noise ratio or introducing computational artifacts in the analysis of emission spectra (17). Once the ringing was properly removed, and each *e* or *f* component correctly measured and identified the process of reducing the line positions into Hamiltonian parameters proceeded in a straight forward manner.

Rapid identification of each of the twelve main branches of each band was performed with the interactive computer program ANALYSIS developed by Pecyner and Davis (18). Each branch was fit to a polynomial in *J* which allowed the correct assignment of the lambda-doubling components and the branches beyond previously measured transitions. Refined estimates were possible by omitting lines that deviated by more than three standard deviations (3σ) from the fit. Initial fitting consisted of developing trial parameters for the upper and lower vibrational states with *v* between 0 and 10. The matrices were diagonalized to obtain the energy sublevels for each *J*-value of the upper and lower states, from which calculated line positions were obtained. Incorrectly identified lines and blends or crossings were rapidly identified from the systematic nature of the residuals. Once the lines within a given band were identified, corrections to the molecular parameters are rapidly calculated. Typically, two iterations were sufficient for the fit to converge and validate constrained parameters, although as bands are combined additional iterations are necessary to allow for readjustment of the parameters to satisfactorily fit all observed lines and bands. 2112 of the 2199 measured line positions are used to calculate 76 molecular parameters with a standard deviation of 0.007 cm^{-1} .

The earlier work of Amiot *et al* (3) fit 1400 line positions to 80 molecular parameters using the unique perturber approximation with an weighted standard deviation of 1.031 cm^{-1} , which translates into an estimated unweighted standard deviation of 0.018 cm^{-1} . The measured infrared line positions were combined with published measurements of microwave and ultraviolet line positions to obtain a more reliable set of molecular parameters, with a calibration error of 0.005 cm^{-1} . Amano (5) measured 124 vibration-rotation lines and Λ -type doubling transition frequencies from which 32 molecular parameters were calculated. The estimated accuracy was 0.001 cm^{-1} and the rms deviation for the fit was 0.0006 cm^{-1} .

In comparison with the work of Amiot *et al* (3), the present work includes 50 % more lines, all measured under similar excitation conditions and a typical estimated accuracy of less than 0.001 cm^{-1} .

The smooth variation of the parameters with increasing vibrational quantum gives an indication of the consistency of the results. The spin-orbit parameters are systematically smaller by 0.2 cm^{-1} than those obtained by Amiot *et al* (3); otherwise, the parameters compare adequately. In the earlier work the parameter A_D displayed an erratic behavior with vibrational quantum number; in contrast, the new parameters display a smooth variation with vibrational quantum number including an unexpected sign change for the $v > 4$ energy levels. Although the error for $A_D(v = 4)$ is larger than the parameter, indicating that there is insufficient information to adequately determine the parameter, for $v > 4$ the parameter is well determined. The work of Amano (5) suggests the kind of work that can be accomplished if the isotopic variants can be utilized simultaneously to remove the indeterminacy implicit in the unique perturber approximation between the parameters A_D and γ . Such a simultaneous analysis is beyond the scope of the present work, but Coxon (20) has expressed interest in combining the data from the various isotopic species of the hydroxyl radical. The spin-orbit parameters for the $v = 0$ and 1 levels compare excellently with the values determined by Amano (5). The values of A_D ($v = 0$) are compatible within the respective uncertainties, but for the $v = 1$ state the results disagree more substantially. The observed line positions and residuals (calculated minus observed) are given in Table 3; the lines are labeled with the traditional F_1 or F_2 , e or f notation. The derived molecular parameters are given in Table 4.

IV. CONCLUSIONS

A new measurement of the infrared spectrum of the OD radical has been made in which many new lines and energy levels are observed for the first time. The source, a diffusion flame permitted the simultaneous observation of 2199 emission lines in the $\Delta v = 1, 2$, and 3 sequences. 2112 of the observed lines were simultaneously fitted to estimate 76 molecular parameters with a standard deviation of 0.007 cm^{-1} , including 35 new parameters.

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Table 1

Summary of observed bands

Delta v	$v' - v''$	P		Q		R	
		a	b	a	b	a	b
1	1-0	58	(17.5)	10	(6.5)	37	(10.5)
	2-1	80	(19.5)	13	(7.5)	36	(10.5)
	3-2	66	(20.5)	13	(7.5)	39	(12.5)
	4-3	74	(19.5)	12	(6.5)	33	(12.5)
	5-4	64	(17.5)	9	(5.5)	24	(6.5)
	6-5	52	(14.5)				
2	2-0	55	(15.5)	8	(5.5)	41	(11.5)
	3-1	61	(19.5)	10	(6.5)	47	(12.5)
	4-2	74	(21.5)	12	(7.5)	49	(13.5)
	5-3	81	(24.5)	14	(7.5)	49	(13.5)
	6-4	85	(24.5)	15	(8.5)	58	(17.5)
	7-5	56	(16.5)	12	(6.5)	50	(13.5)
	8-6	51	(14.5)	14	(7.5)	45	(13.5)
	9-7	81	(22.5)	13	(7.5)	40	(11.5)
	10-8	73	(21.5)			41	(11.5)
3	5-2	38	(11.5)				
	6-3	44	(13.5)				
	7-4	48	(16.5)			26	(9.5)
	8-5	58	(17.5)			32	(12.5)
	9-6	58	(16.5)	6	(3.5)	28	(7.5)
	10-7	66	(18.5)			25	(9.5)

(a) The number of observed lines in each branch.

(b) The maximum observed J-value in each branch.

Table 2
**Matrix Elements of the UPA Hamiltonian for a $^2\Pi$ State in an e/f Symmetrized,
Hund's case (a) Basis Set**

T	1, 1	1	p	1, 2 $-0.25z^{0.5}$
	2, 2	1		2, 2 $0.5(1 \mp (J + 0.5))$
A	1, 1	0.5	p_D	1, 2 $-0.25z^{0.5}J(J + 1)$
	2, 2	-0.5		2, 2 $0.5(1 \mp (J + 0.5))J(J + 1)$
A_D	1, 1	$0.5(z - 1)$	p_H	1, 2 $-0.25z^{0.5}J^2(J + 1)^2$
	2, 2	$-0.5(z + 1)$		2, 2 $0.5(1 \mp (J + 0.5))J^2(J + 1)^2$
A_H	1, 1	$0.25(3(z - 1)^2 + z)$	q	1, 1 $0.5z$
	2, 2	$-0.25(3(z + 1)^2 + z)$		2, 2 $0.5(z + 2 \mp (J + 0.5))$
	1, 2	$0.5z^{0.5}$		1, 2 $0.5z^{0.5}(-1 \pm (J + 0.5))$
B	1, 1	$z - 1$	q_D	1, 1 $0.5zJ(J + 1)$
	2, 2	$z + 1$		2, 2 $0.5(z + 2 \mp (J + 0.5))J(J + 1)$
	1, 2	$-z^{0.5}$		1, 2 $0.5z^{0.5}(-1 \pm (J + 0.5))J^2(J + 1)^2$
D	1, 1	$-(z - 1)^2 - z$	q_H	1, 1 $0.5zJ^2(J + 1)^2$
	2, 2	$-(z + 1)^2 - z$		2, 2 $0.5(z + 2 \mp (J + 0.5))J^2(J + 1)^2$
	1, 2	$2z^{1.5}$		1, 2 $0.5z^{0.5}(-1 \pm (J + 0.5))J^2(J + 1)^2$
H	1, 1	$(z - 1)^3 + z(3z - 1)$	γ	1, 1 0.5
	2, 2	$(z + 1)^3 + z(3z + 1)$		2, 2 -0.5
	1, 2	$-(3z^2 + z + 1)z^{0.5}$		1, 2 $0.5z^{0.5}$
L	1, 1	$(z - 1)^4 + z(6z^2 - 3z + 2)$	γ_D	1, 1 $0.5J(J + 1)$
	2, 2	$(z + 1)^4 + z(6z^2 + 5z + 2)$		2, 2 $-0.5J(J + 1)$
	1, 2	$-4z^{1.5}(z^2 + z + 1)$		1, 2 $\pm 0.5z^{0.5}J^2(J + 1)^2$
o	2, 2	1	γ_H	1, 1 $-0.5J^2(J + 1)^2$
				2, 2 $-0.5J^2(J + 1)^2$
				1, 2 $0.5z^{0.5}J^2(J + 1)^2$

^a The matrix elements are given for the e and f parity sublevels with $z = (J + \frac{1}{2})^2 - 1$. When a sign is given, the upper sign refers to the e sublevels, and the lower sign refers to the f sublevels.

Table - 3

Observed line positions of 1-0 band of OD

J	p1e	c-o	p1f	c-o	p2e	c-o	p2f	c-o
1.5					2600.4738	-22	2600.3757	19
2.5	2585.1087	131	2585.1087	-167	2578.6865	-11	2578.6062	17
3.5	2565.2174	4	2565.1606	7	2556.4431	-4	2556.3859	26
4.5	2544.7171	5	2544.6286	14	2533.7707	150	2533.7707	-109
5.5					2510.7420	-6	2510.7420	38
6.5	2501.9421	7	2501.7851	18	2487.3403	-164	2487.3403	194
7.5	2479.7009	5	2479.5089	19	2463.5394	5	2463.6052	20
8.5	2456.9214	4	2456.6953	15	2439.3924	5	2439.4895	17
9.5	2433.6291	1	2433.3688	18	2414.8821	33	2415.0132	8
10.5	2409.8489	-4	2409.5556	13	2390.0203	1	2390.1783	3
11.5	2385.6040	-8	2385.2784	9	2364.8020	2	2364.9902	-6
12.5	2360.9173	-17	2360.5597	2	2339.2366	1	2339.4542	-16
13.5	2335.8078	-9	2335.4203	-4	2313.3317	-5	2313.5773	-24
14.5	2310.2987	-20	2309.8797	-9	2287.0932	5	2287.3669	-17
15.5	2284.4047	-9	2283.9563	-10	2260.5334	7	2260.8314	13
16.5	2258.1461	0	2257.6676	-2	2233.6598	28	2233.9836	45
17.5	2231.5403	7	2231.0327	-6				

J	r1e	c-o	r1f	c-o	r2e	c-o	r2f	c-o
.5					2662.3642	63	2662.4587	-28
1.5	2676.6656	31	2676.6920	36	2681.7079	2	2681.7754	-22
2.5	2693.6165	14	2693.6676	-9	2700.3024	-18	2700.3396	11
3.5	2710.1418	12	2710.2152	7	2718.1351	-72	2718.1351	60
4.5	2726.2236	9	2726.3204	9	2735.1788	71	2735.1788	-64
5.5	2741.8340	-5	2741.9534	-2	2751.4805	-5	2751.4412	-4
6.5	2756.9368	10	2757.0762	21	2767.0199	-5	2766.9556	8
7.5	2771.5051	7	2771.6642	8	2781.8151	-15	2781.7403	-111
8.5	2785.5029	49	2785.6819	17	2795.8702	1	2795.7642	25
9.5	2798.9164	12	2799.1030	48				
10.5			2811.9146	2				

J	q1e	c-o	q1f	c-o
1.5	2631.5068	-92	2631.3779	999
2.5	2630.2430	2	2630.3221	-21
3.5	2628.4636	-42	2628.6408	3
4.5	2626.2094	-775	2626.4721	21
5.5			2623.8454	-342
6.5			2620.6525	-72

Table - 3

Observed line positions of 2-1 band of OD

J	p1e	c-o	p1f	c-o	p2e	c-o	p2f	c-o
1.5					2513.1068	-2	2513.0119	25
2.5	2498.0587	0	2498.0306	0	2491.9388	2	2491.8597	18
3.5	2478.6709	-14	2478.6157	4	2470.3105	4	2470.2530	21
4.5	2458.7001	-5	2458.6161	0	2448.2599	40	2448.2301	41
5.5	2438.1489	-3	2438.0323	1	2425.8236	7	2425.8214	21
6.5	2417.0272	2	2416.8773	2	2403.0047	33	2403.0354	20
7.5	2395.3543	4	2395.1704	4	2379.8216	18	2379.8833	0
8.5	2373.1520	8	2372.9346	6	2356.2738	13	2356.3652	1
9.5	2350.4445	8	2350.1937	8	2332.3658	9	2332.4874	-5
10.5	2327.2541	16	2326.9716	6	2308.1008	10	2308.2509	4
11.5	2303.6050	15	2303.2904	6	2283.4839	14	2283.6646	-5
12.5	2279.5331	-138	2279.1720	3	2258.5226	6	2258.7308	-2
13.5	2255.0121	20	2254.6357	4	2233.2233	-8	2233.4571	10
14.5	2230.1077	23	2229.7022	-4	2207.5914	0	2207.8788	-236
15.5	2204.8232	21	2204.3867	2	2181.6382	5	2181.9323	-15
16.5	2179.1765	6	2178.7034	55	2155.3784	-36	2155.6933	12
17.5	2153.1802	18	2152.6857	-11	2128.8035	60	2129.1527	46
18.5	2126.8527	30	2126.3300	-8	2101.9499	39		
19.5					2074.8250	-61		

J	r1e	c-o	r1f	c-o	r2e	c-o	r2f	c-o
.5					2573.1738	16	2573.2590	-20
1.5	2587.1673	-16	2587.1923	-14	2591.9245	16	2591.9896	-17
2.5	2603.6233	14	2603.6717	-11	2609.9490	2	2609.9880	-11
3.5	2619.6545	8	2619.7246	-9	2627.2309	-63	2627.2309	53
4.5	2635.2389	2	2635.3300	1	2643.7400	67	2643.7400	-75
5.5	2650.3490	8	2650.4634	-9	2659.5213	-23	2659.4834	-33
6.5	2664.9628	-55	2665.0917	-22	2674.5489	-1	2674.4851	21
7.5	2679.0312	1	2679.1822	-9	2688.8244	196	2688.7613	9
8.5			2692.7055	40	2702.4261	-148	2702.3124	-9
9.5	2705.4683	20	2705.6475	14				
10.5	2717.7866	5						

J	q1e	c-o	q1f	c-o
1.5	2543.2206	-105	2543.2206	81
2.5	2541.9674	1	2542.0396	-1
3.5	2540.2013	1	2540.3718	8
4.5	2537.8974	14	2538.2236	-16
5.5	2535.0496	1	2535.5838	-38
6.5	2531.6446	28	2532.4419	-18
7.5	2527.6826	54		

Table - 3

Observed line positions of 3-2 band of OD

J	p1e	c-o	p1f	c-o	p2e	c-o	p2f	c-o
1.5					2426.6213	6	2426.5297	36
2.5	2411.8697	147	2411.8697	-116	2406.0631	5	2405.9853	35
3.5	2393.0014	7	2392.9489	29	2385.0406	2	2384.9837	27
4.5	2373.5519	8	2373.4724	16	2363.5772	161	2363.5772	-133
5.5	2353.5356	-1	2353.4246	10	2341.7463	19	2341.7463	0
6.5	2332.9602	-4	2332.8172	3	2319.5355	-132	2319.5355	136
7.5	2311.8435	-9	2311.6674	1	2296.9246	4	2296.9823	-11
8.5	2290.2059	-16	2289.9967	-1	2273.9629	0	2274.0491	-13
9.5	2268.0688	-18	2267.8275	-4	2250.6401	0	2250.7552	-15
10.5	2245.4548	-16	2245.1818	-4	2226.9613	0	2227.1047	-17
11.5	2222.3855	-13	2222.0816	-5	2202.9311	5	2203.1026	-14
12.5	2198.8811	-3	2198.5466	0	2178.5559	12	2178.7562	-21
13.5	2174.9623	0	2174.5970	4	2153.8442	7	2154.0695	-5
14.5	2150.6460	13	2150.2508	10	2128.8035	-6	2129.0560	-21
15.5	2125.9485	47	2125.5260	13	2103.4371	23	2103.7150	24
16.5	2100.8908	56	2100.4427	-26			2078.0650	38
17.5			2074.9944	115			2052.1301	-122
18.5			2049.2441	-44			2025.9878	-999
19.5							1999.4115	-632
20.5							1972.4973	520

J	r1e	c-o	r1f	c-o	r2e	c-o	r2f	c-o
.5					2484.8801	31	2484.9625	-1
1.5	2498.5780	-98	2498.5780	138	2503.0487	23	2503.1122	-4
2.5	2514.5366	20	2514.5802	15	2520.5054	15	2520.5467	-17
3.5	2530.0735	15	2530.1384	13	2537.2386	-74	2537.2386	60
4.5	2545.1602	9	2545.2470	5	2553.2131	38	2553.2131	-74
5.5	2559.7725	-1	2559.8796	-1	2568.4489	168	2568.4489	-180
6.5	2573.8808	1	2574.0063	7	2582.9862	-28	2582.9285	-17
7.5	2587.4598	-14	2587.5965	48	2596.7827	-64	2596.7031	-32
8.5	2600.4736	44	2600.6398	-39				
9.5	2612.9156	0	2613.0875	-15	2622.2033	34		
10.5							2633.7381	-98
11.5	2635.9704	-115	2636.1327	150				
12.5	2646.5016	259						

J	q1e	c-o	q1f	c-o
1.5	2455.8300	-87	2455.8300	87
2.5	2454.5854	20	2454.6533	16
3.5	2452.8342	12	2452.9952	11
4.5	2450.5492	35	2450.8570	0
5.5	2447.7288	9	2448.2466	-164
6.5	2444.3586	11	2445.1100	-4
7.5			2441.4894	4

Table - 3

Observed line positions of 4-3 band of OD

J	p1e	c-o	p1f	c-o	p2e	c-o	p2f	c-o
1.5					2340.8133	-5	2340.7244	20
2.5	2326.3743	125	2326.3743	-121	2320.8549	13	2320.7790	33
3.5	2308.0071	-7	2307.9576	12	2300.4303	7	2300.3733	26
4.5	2289.0709	1	2288.9958	6	2279.5456	296	2279.5456	-22
5.5	2269.5789	7	2269.4742	7	2258.3112	45	2258.3112	-12
6.5	2249.5396	7	2249.4033	9	2236.6796	-94	2236.6796	122
7.5	2228.9672	8	2228.7987	12	2214.6463	28	2214.6994	-5
8.5	2207.8788	26	2207.6804	11	2192.2582	19	2192.3387	-7
9.5	2186.3005	6	2186.0611	86	2169.5071	15	2169.6150	-9
10.5	2164.2476	3	2163.9845	9	2146.3988	8	2146.5404	-78
11.5	2141.7421	2	2141.4487	8	2122.9374	16	2123.1002	-13
12.5	2118.8053	-10	2118.4793	21	2099.1323	7	2099.3224	-30
13.5	2095.4521	1	2095.0997	3	2074.9944	-54	2075.2063	-50
14.5	2071.7046	-3	2071.3227	4	2050.5148	0	2050.7571	-43
15.5	2047.5788	-13	2047.1681	-1	2025.7180	12	2025.9878	-52
16.5	2023.0899	-18	2022.6512	-6	2000.5818	298	2000.9052	-49
17.5	1998.2543	-25	1997.7855	11	1975.2025	-6	1975.5190	-36
18.5	1973.0829	4	1972.5859	51	1949.4986	13	1949.8388	-4
19.5	1947.5991	-15	1947.0763	21	1923.5149	15	1923.8795	-1
J	r1e	c-o	r1f	c-o	r2e	c-o	r2f	c-o
.5					2397.2844	8	2397.3628	-21
1.5	2410.6715	-109	2410.6715	111	2414.8818	-74	2414.9386	-65
2.5	2426.1407	32	2426.1845	-3	2431.7672	-16	2431.8020	-4
3.5	2441.1873	6	2441.2492	-7	2447.9464	-70	2447.9464	53
4.5	2455.7696	76	2455.8300	280	2463.3828	47	2463.3828	-65
5.5	2469.8915	-23	2469.9886	7	2478.0924	178	2478.0924	-159
6.5	2483.4968	4	2483.6155	-1	2492.1128	-15	2492.0599	-31
7.5	2496.5725	25	2496.7089	0			2505.3353	-132
8.5	2509.0994	-28			2529.8228	46		
9.5							2551.2564	393
11.5					2561.1352	141		
J	q1e	c-o	q1f	c-o				
1.5	2369.1257	-93	2369.1257	70				
2.5	2367.8834	65	2367.9550	-18				
3.5	2366.1490	7	2366.3010	-4				
4.5	2363.8881	-43	2364.1768	-70				
5.5	2361.0812	12	2361.5596	-56				
6.5	2357.7362	30	2358.4502	-29				

Table - 3

Observed line positions of 5-4 band of OD

J	p1e	c-o	p1f	c-o	p2e	c-o	p2f	c-o
1.5					2255.4452	32	2255.3656	0
2.5	2241.3318	113	2241.3318	-118	2236.0868	-7	2236.0126	20
3.5	2223.4581	-6	2223.4115	14	2216.2500	0	2216.1934	25
4.5	2205.0275	1	2204.9567	4	2195.9596	169	2195.9596	-151
5.5	2186.0611	-92	2185.9521	3	2175.2875	50	2175.2875	-21
6.5	2166.5367	5	2166.4069	5	2154.2246	-82	2154.2246	109
7.5	2146.4970	1	2146.3352	9	2132.7570	26	2132.8057	2
8.5	2125.9485	0	2125.7560	4	2110.9295	14	2111.0034	9
9.5	2104.9097	9	2104.6875	0	2088.7351	15	2088.8369	2
10.5	2083.4019	10	2083.1488	4	2066.1816	11	2066.3101	-5
11.5	2061.4443	5	2061.1612	0	2043.2737	12	2043.4290	-10
12.5	2039.0540	12	2038.7418	3	2020.0193	7	2020.2006	-20
13.5	2016.2513	8	2015.9100	0	1996.4241	12	1996.6308	-19
14.5	1993.0513	12	1992.6826	-4	1972.4973	12	1972.7288	-21
15.5	1969.4731	0	1969.0750	0	1948.2468	15	1948.5032	-27
16.5	1945.5262	32	1945.1011	30	1923.6797	40	1923.9639	-46
17.5	1921.2429	-64	1920.7835	11				
J	r1e	c-o	r1f	c-o	r2e	c-o	r2f	c-o
.5					2310.1491	-13	2310.1491	711
1.5	2323.2241	-95	2323.2241	109	2327.1585	7	2327.1585	566
2.5	2338.2106	-13	2338.2481	-15	2343.4892	-44	2343.4892	310
3.5	2352.7559	20	2352.8149	-6	2359.1122	-72	2359.1122	61
4.5	2366.8475	-8	2366.9202	16	2374.0076	31	2374.0076	-56
5.5	2380.4549	-9	2380.5477	-3	2388.1813	195	2388.1813	-104
6.5	2393.5538	16	2393.6646	8				
J	q1e	c-o	q1f	c-o				
1.5	2282.8783	-72	2282.8783	79				
2.5	2281.6478	5	2281.7082	-9				
3.5	2279.9138	11	2280.0570	-12				
4.5	2277.6594	0	2277.9304	-35				
5.5	2274.8729	-5						

Table - 3

Observed line positions of 6-5 band of OD

J	p1e	c-o	p1f	c-o	p2e	c-o	p2f	c-o
1.5					2170.2657	-23	2170.1752	83
2.5	2156.4762	111	2156.4762	-104	2151.4888	0	2151.4175	18
3.5	2139.0918	-5	2139.0492	5	2132.2352	-5	2132.1781	31
4.5	2121.1597	-3	2121.0929	5	2112.5177	178	2112.5177	-152
5.5	2102.6897	2	2102.5960	8	2092.4129	50	2092.4129	-49
6.5	2083.6890	1	2083.5674	-3	2071.9079	-72	2071.9079	74
7.5	2064.1687	-1	2064.0165	3	2050.9954	11	2051.0378	-11
8.5	2044.1440	1	2043.9620	4	2029.7140	9	2029.7820	-13
9.5	2023.6339	-6	2023.4201	15	2008.0612	19	2008.1562	-20
10.5	2002.6552	-7	2002.4120	11	1986.0455	19	1986.1663	-28
11.5	1981.2264	-4	1980.9543	11	1963.6720	23	1963.8195	-45
12.5	1959.3661	-4	1959.0650	11	1940.9476	28	1941.1195	-41
13.5	1937.0908	0	1936.7608	18	1917.9569	-737	1918.0797	-78
14.5	1914.4189	-9	1914.0606	6				

Table - 3

Observed line positions of 2-0 band of OD

J	p1e	c-o	p1f	c-o	p2e	c-o	p2f	c-o
1.5					5144.0673	-2	5143.9661	33
2.5	5128.3283	131	5128.3283	-172	5121.3722	-1	5121.2863	14
3.5	5107.2237	-12	5107.1605	32	5097.6213	-1	5097.5570	12
4.5	5085.0079	-4	5084.9144	0	5072.8487	186	5072.8487	-168
5.5	5061.6924	-53	5061.5544	16	5047.1449	32	5047.1449	-9
6.5	5037.2620	33	5037.0932	8	5020.5019	-137	5020.5019	156
7.5	5011.7558	3	5011.5418	17	4992.9007	19	4992.9657	11
8.5	4985.1774	16	4984.9230	15	4964.4014	9	4964.5016	4
9.5	4957.5554	8	4957.2665	-69	4934.9952	0	4935.1289	17
10.5	4928.9085	25	4928.5709	11	4904.6810	76	4904.8596	7
11.5	4899.2663	3	4898.8848	5	4873.4915	-6	4873.6975	14
12.5	4868.6457	1	4868.2214	7	4841.4095	11	4841.6566	-9
13.5	4837.0718	-9	4836.6076	-33	4808.4586	-2	4808.7414	-8
14.5	4804.5629	-2	4804.0538	-6	4774.6662	-212	4774.9788	-138
15.5							4740.3322	87

J	r1e	c-o	r1f	c-o	r2e	c-o	r2f	c-o
.5					5205.0592	-20	5205.1392	-36
1.5	5218.6878	-143	5218.6878	101	5222.8864	2	5222.9455	-25
2.5	5233.9098	-22	5233.9531	-20	5239.3967	-144	5239.3967	162
3.5	5248.2076	7	5248.2724	-9	5254.5379	-31	5254.5379	14
4.5	5261.5461	9	5261.6289	-3	5268.3401	101	5268.3401	-99
5.5	5273.8863	19	5273.9872	-13	5280.8163	265	5280.8163	-158
6.5	5285.1937	13	5285.3056	3	5292.0290	-1	5291.9684	-11
7.5	5295.4320	7	5295.5528	11	5301.9242	-9	5301.8452	6
8.5	5304.5702	2	5304.6998	-9	5310.5401	-15	5310.4475	8
9.5	5312.5820	-7	5312.7130	10				
10.5	5319.4444	-20	5319.5788	-18	5323.9649	-10		
11.5	5325.1094	254			5328.7937	-103		

J	q1e	c-o	q1f	c-o
1.5	5174.7281	-109	5174.7281	83
2.5	5172.2462	17	5172.3233	-10
3.5	5168.7499	-8	5168.9261	-5
4.5	5164.1926	45	5164.5288	9

Table - 3

Observed line positions of 3-1 band of OD

J	p1e	c-o	p1f	c-o	p2e	c-o	p2f	c-o
1.5					4969.3107	-21	4969.2114	16
2.5	4953.8734	156	4953.8734	-130	4947.2407	14	4947.1559	26
3.5	4933.2913	5	4933.2351	11	4924.1222	2	4924.0553	33
4.5	4911.6177	3	4911.5287	8	4899.9801	200	4899.9801	-180
5.5	4888.8581	-1	4888.7321	7	4874.9076	49	4874.9076	-34
6.5	4865.0152	-6	4864.8498	5	4848.8966	-115	4848.8966	123
7.5	4840.1006	-7	4839.8949	2	4821.9347	-1	4821.9932	-12
8.5	4814.1323	-10	4813.8856	-1	4794.0725	0	4794.1663	-17
9.5	4787.1305	-9	4786.8423	0	4765.3087	-5	4765.4367	-14
10.5	4759.1176	-10	4758.7879	-4	4735.6503	-5	4735.8145	-20
11.5	4730.1150	-6	4729.7442	-10	4705.1061	-6	4705.3049	-6
12.5	4700.1440	6	4699.7318	-7	4673.6851	-7	4673.9194	2
13.5	4669.2273	10	4668.7718	1	4641.3978	-16	4641.6761	-72
14.5	4637.3827	30	4636.8871	-10	4608.2392	120	4608.5578	43
15.5	4604.6388	-22	4604.0931	0	4574.2630	-18		
16.5	4570.9912	85	4570.4131	-14				
18.5	4501.1279	80						
19.5	4464.9612	-172						

J	r1e	c-o	r1f	c-o	r2e	c-o	r2f	c-o
.5					5028.4772	15	5028.5552	-11
1.5	5041.7988	-108	5041.7988	121	5045.7355	21	5045.7930	-15
2.5	5056.5463	-31	5056.5862	-21	5061.6924	-69	5061.6924	223
3.5	5070.3645	3	5070.4241	0	5076.3158	-30	5076.3158	9
4.5	5083.2264	-1	5083.3035	-5	5089.6148	88	5089.6148	-110
5.5	5095.0960	-11	5095.1874	-7	5101.6305	-4	5101.5906	-18
6.5	5105.9363	-7	5106.0410	-13	5112.3482	-20	5112.2888	-22
7.5	5115.7162	-6	5115.8302	-12	5121.7875	-19	5121.7126	-18
8.5	5124.4060	-9	5124.5254	-6	5129.9606	-14	5129.8726	0
9.5	5131.9781	0	5132.1029	-18	5136.8782	-32	5136.7778	19
10.5	5138.4122	2	5138.5367	-8	5142.5383	-1	5142.4343	33
11.5	5143.6864	26	5143.8069	30	5146.9548	-32	5146.8494	-6
12.5	5147.7964	-49						

J	q1e	c-o	q1f	c-o
1.5			4999.0485	99
2.5	4996.5889	8	4996.6589	7
3.5	4993.1197	1	4993.2859	2
4.5	4988.6070	12	4988.9210	12
5.5	4983.0340	28	4983.5540	-12
6.5			4977.1642	1

Table - 3

Observed line positions of 4-2 band of OD

J	p1e	c-o	p1f	c-o	p2e	c-o	p2f	c-o
1.5					4796.1149	10	4796.0202	33
2.5	4780.9942	149	4780.9942	-119	4774.6662	14	4774.5829	30
3.5	4760.9241	6	4760.8706	16	4752.1667	6	4752.1012	26
4.5	4739.7799	6	4739.6957	10	4728.6625	9	4728.6225	15
5.5	4717.5666	2	4717.4468	9	4704.1862	65	4704.1862	-47
6.5	4694.2857	-2	4694.1279	5	4678.7906	-94	4678.7906	98
7.5	4669.9473	-9	4669.7500	2	4652.4462	3	4652.4992	-11
8.5	4644.5667	-10	4644.3290	2	4625.2017	0	4625.2883	-18
9.5	4618.1634	-13	4617.8849	0	4597.0565	0	4597.1771	-19
10.5	4590.7572	-13	4590.4377	-1	4568.0199	-1	4568.1749	-21
11.5	4562.3692	-14	4562.0084	-2	4538.1009	-7	4538.2897	-16
12.5	4533.0186	-1	4532.6169	1	4507.3075	-7	4507.5313	-13
13.5	4502.7277	2	4502.2845	-1	4475.6491	-1	4475.9090	-8
14.5	4471.5142	13	4471.0303	-10	4443.1374	-2	4443.4312	19
15.5	4439.3975	26	4438.8700	4	4409.7835	-13	4410.1126	32
16.5	4406.3962	35	4405.8271	-10	4375.5972	-19	4375.9646	29
17.5	4372.5291	28	4371.9168	-33			4340.9932	69
18.5	4337.8062	74					4305.2215	42
19.5	4302.2580	31						
20.5	4265.8894	11						
21.5	4228.7293	-126						

J	r1e	c-o	r1f	c-o	r2e	c-o	r2f	c-o
.5					4853.4846	26	4853.5606	-11
1.5	4866.4999	-90	4866.4999	123	4870.1755	20	4870.2305	-13
2.5	4880.7832	-169	4880.7832	211	4885.5913	-142	4885.5913	138
3.5	4894.1057	7	4894.1607	11	4899.6785	-29	4899.6785	10
4.5	4906.4868	-1	4906.5580	4	4912.4675	82	4912.4675	-105
5.5	4917.8763	-1	4917.9619	2	4923.9686	185	4923.9686	-207
6.5	4928.2429	-6	4928.3395	1	4934.2242	-19	4934.1668	-14
7.5	4937.5544	-11	4937.6595	-2	4943.1949	-22	4943.1218	-4
8.5	4945.7817	-9	4945.8925	-4	4950.9166	-85	4950.8257	-1
9.5	4952.8989	2	4953.0137	-7	4957.3787	-32	4957.2665	184
10.5	4958.8868	0	4959.0003	-1	4962.6042	-50	4962.4995	45
11.5	4963.7239	5	4963.8365	-17	4966.5873	-56	4966.4779	70
12.5	4967.3941	16	4967.5033	-32				
13.5			4969.9861	-43				

J	q1e	c-o	q1f	c-o
1.5	4824.9529	-68		
2.5	4822.5083	17	4822.5743	11
3.5	4819.0612	19	4819.2183	7
4.5	4814.5816	25	4814.8787	4
5.5	4809.0559	-6	4809.5414	-2
6.5	4802.4623	12	4803.1934	-11
7.5	4794.8001	1		

Table - 3

Observed line positions of 5-3 band of OD

J	p1e	c-o	p1f	c-o	p2e	c-o	p2f	c-o
1.5					4624.0531	-4	4623.9605	21
2.5	4609.2536	122	4609.2536	-131	4603.2128	-1	4603.1303	17
3.5	4589.6854	-2	4589.6355	0	4581.3192	8	4581.2546	14
4.5	4569.0589	0	4568.9791	1	4558.4197	12	4558.3782	12
5.5	4547.3770	3	4547.2629	5	4534.5427	88	4534.5427	-60
6.5	4524.6403	7	4524.4894	7	4509.7436	-58	4509.7436	88
7.5	4500.8574	11	4500.6681	7	4483.9968	17	4484.0439	6
8.5	4476.0423	12	4475.8134	8	4457.3464	10	4457.4260	-1
9.5	4450.2118	15	4449.9431	6	4429.7960	-7	4429.9073	-4
10.5	4423.3853	12	4423.0757	7	4401.3510	2	4401.4966	-1
11.5	4395.5798	28	4395.2318	0	4372.0248	-2	4372.2050	-11
12.5	4366.8201	7	4366.4293	-2	4341.8250	-8	4342.0392	-14
13.5	4337.1205	-2	4336.6879	-5	4310.7603	-6	4311.0096	-14
14.5	4306.4994	0	4306.0264	-10	4278.8427	-15	4279.1255	-4
15.5	4274.9774	-10	4274.4621	-11	4246.0812	-17	4246.3986	4
16.5	4242.5701	-15	4242.0131	-14	4212.4875	-17	4212.8414	1
17.5	4209.2952	-23	4208.6962	-17	4178.0762	-46	4178.4600	38
18.5	4175.1682	-23	4174.5262	-4	4142.8524	-38	4143.2741	40
19.5	4140.2051	-14	4139.5268	-50	4106.8275	15		
20.5	4104.4224	-7	4103.6972	7				
21.5	4067.8396	-43	4067.0694	2				
22.5	4030.4579	11	4029.6455	62				
23.5	3992.3094	-18						
24.5	3953.3903	41						

J	r1e	c-o	r1f	c-o	r2e	c-o	r2f	c-o
.5					4679.6412	4	4679.7127	-23
1.5	4692.3497	-102	4692.3497	95	4695.7626	7	4695.8147	-25
2.5	4706.1493	-173	4706.1493	178	4710.6255	-141	4710.6255	121
3.5	4718.9857	0	4719.0376	-7	4724.1779	-28	4724.1779	5
4.5	4730.8775	4	4730.9443	-3	4736.4472	80	4736.4472	-102
5.5	4741.7788	7	4741.8586	-4	4747.4421	175	4747.4421	-199
6.5	4751.6582	11	4751.7479	2	4757.1989	-3	4757.1445	1
7.5	4760.4859	12	4760.5828	2	4765.6835	-15	4765.6134	14
8.5	4768.2331	20	4768.3354	-1	4772.9195	-14	4772.8384	25
9.5	4774.8762	22	4774.9788	13	4778.9150	-20	4778.8233	57
10.5	4780.3931	23	4780.4957	0	4783.6732	-30	4783.5751	73
11.5	4784.7648	23	4784.8642	-8			4787.1965	-938
12.5	4787.9770	-2	4788.0706	-40			4789.4820	-923
13.5	4790.0074	22						

Table - 3

Observed line positions of 5-3 band of OD - cont.

J	q1e	c-o	q1f	c-o
1.5	4652.0035	-83	4652.0035	74
2.5	4649.5689	-1	4649.6301	-3
3.5	4646.1376	0	4646.2842	-7
4.5	4641.6761	54	4641.9589	-7
5.5	4636.1822	10	4636.6400	-1
6.5	4629.6274	23	4630.3158	3
7.5	4622.0125	-4	4622.9794	-26

Table - 3

Observed line positions of 6-4 band of OD

J	p1e	c-o	p1f	c-o	p2e	c-o	p2f	c-o
1.5					4452.6220	-21	4452.5323	7
2.5	4438.1545	117	4438.1545	-119	4432.3798	-19	4432.2990	5
3.5	4419.0793	-1	4419.0326	0	4411.0816	-12	4411.0167	6
4.5	4398.9572	0	4398.8818	1	4388.7721	-8	4388.7286	5
5.5	4377.7906	0	4377.6824	3	4365.4769	87	4365.4769	-83
6.5	4355.5793	1	4355.4355	4	4341.2552	-51	4341.2552	57
7.5	4332.3305	1	4332.1490	5	4316.0834	5	4316.0834	411
8.5	4308.0570	-7	4307.8360	5	4290.0009	7	4290.0734	-1
9.5	4282.7716	2	4282.5121	5	4263.0138	9	4263.1185	-5
10.5	4256.4944	2	4256.1950	4	4235.1318	11	4235.2694	-10
11.5	4229.2422	3	4228.9034	-3	4206.3638	15	4206.5343	-8
12.5	4201.0334	2	4200.6534	1	4176.7197	14	4176.9238	-14
13.5	4171.8858	2	4171.4644	3	4146.2074	21	4146.4458	-16
14.5	4141.8164	4	4141.3542	1	4114.8395	9	4115.1108	-21
15.5	4110.8420	11	4110.3394	-3	4082.6214	22	4082.9272	-12
16.5	4078.9822	-6	4078.4360	-5	4049.5674	20	4049.9079	-14
17.5	4046.2464	13	4045.6588	2	4015.6848	37	4016.0629	-22
18.5	4012.6561	8	4012.0258	-2	3980.9908	10	3981.3895	100
19.5	3978.2214	28	3977.5505	-8	3945.4883	17	3945.8901	437
20.5	3942.9673	-33	3942.2492	-36	3909.1904	37	3909.6743	2
21.5	3906.8885	12	3906.1327	-56	3872.1120	26		
22.5	3870.0190	-41	3869.2099	-22				
23.5	3832.3489	32						
24.5	3793.9166	-28						

J	r1e	c-o	r1f	c-o	r2e	c-o	r2f	c-o
.5					4506.4400	-4	4506.5093	-41
1.5	4518.8458	-95	4518.8458	89	4521.9906	-8	4522.0402	-37
2.5	4532.1551	-163	4532.1551	163	4536.2948	-153	4536.2948	100
3.5	4544.4967	2	4544.5450	-5	4549.3021	-41	4549.3021	-5
4.5	4555.8889	0	4555.9506	-3	4561.0378	67	4561.0378	-103
5.5	4566.2873	2	4566.3609	-2	4571.5090	160	4571.5090	-195
6.5	4575.6630	1	4575.7455	0	4580.7490	-12	4580.6963	2
7.5	4583.9860	9	4584.0758	-3	4588.7226	-15	4588.6553	18
8.5	4591.2310	7	4591.3231	5	4595.4533	-14	4595.3755	28
9.5	4597.3724	10	4597.4659	-2	4600.9470	-21	4600.8592	56
10.5	4602.3889	13	4602.4811	-10	4605.2080	-54	4605.1120	72
11.5	4606.2616	16	4606.3493	-16	4608.2392	-133	4608.1306	115
12.5	4608.9737	16	4609.0533	-15	4610.0177	-41	4609.9179	145
13.5	4610.5021	94	4610.5763	9	4610.5763	-128	4610.5021	-144
14.5	4610.8555	27	4610.9154	-49	4609.9179	-460		
15.5	4610.0177	-144	4610.0177	216	4607.9489	-141		
16.5			4607.9489	37				
17.5			4604.6388	10				

Table - 3

Observed line positions of 6-4 band of OD - cont.

J	q1e	c-o	q1f	c-o
1.5	4479.7016	-75	4479.7016	71
2.5	4477.2700	0	4477.3279	-10
3.5	4473.8443	2	4473.9801	4
4.5	4469.3982	0	4469.6576	-5
5.5	4463.9127	19	4464.3445	-17
6.5	4457.3464	343	4458.0270	-14
7.5	4449.7878	-6	4450.7014	-59
8.5			4442.3457	-11

Table - 3

Observed line positions of 7-5 band of OD

J	p1e	c-o	p1f	c-o	p2e	c-o	p2f	c-o
1.5					4281.2483	41	4281.1616	62
2.5	4267.1265	119	4267.1265	-102	4261.5948	45	4261.5157	52
3.5	4248.5347	7	4248.4908	8	4240.8800	43	4240.8141	48
4.5	4228.9034	9	4228.8330	2	4219.1447	43	4219.0996	29
5.5	4208.2359	2	4208.1336	-2	4196.4140	141	4196.4140	-93
6.5	4186.5298	0	4186.3929	-8	4172.7482	-1	4172.7482	26
7.5	4163.7911	-3	4163.6176	-12	4148.1441	-153	4148.1441	159
8.5	4140.0305	-4	4139.8190	-17	4122.5848	8	4122.6496	-27
9.5	4115.2615	-4	4115.0115	-23	4096.1307	0	4096.2267	-37
10.5	4089.5000	-2	4089.2106	-25	4068.7746	-2	4068.9027	-43
11.5	4062.7624	1	4062.4330	-21	4040.5259	1	4040.7978	-999
12.5	4035.0659	2	4034.6961	-18	4011.3945	1		
13.5	4006.4258	13	4006.0159	-8	3981.3895	-1		
14.5	3976.8598	21	3976.4091	5	3950.5152	39		
15.5	3946.3839	21	3945.8901	36	3918.7883	52		
16.5	3915.0109	38	3914.4769	55				

J	r1e	c-o	r1f	c-o	r2e	c-o	r2f	c-o
.5					4333.3045	56	4333.3688	17
1.5	4345.4096	-80	4345.4096	87	4348.2784	44	4348.3246	0
2.5	4358.2191	-143	4358.2191	153	4362.0129	-88	4362.0129	119
3.5	4370.0547	4	4370.0988	-7	4374.4622	1	4374.4622	0
4.5	4380.9316	2	4380.9884	-14	4385.6471	91	4385.6471	-108
5.5	4390.8088	2	4390.8763	-20	4395.5798	98	4395.5798	-275
6.5	4399.6587	0	4399.7340	-26	4404.2710	-19	4404.2190	-18
7.5	4407.4525	1	4407.5332	-29	4411.7037	-23	4411.6391	-9
8.5	4414.1644	4	4414.2474	-29	4417.8959	-38	4417.8189	16
9.5	4419.7712	2	4419.8530	-28	4422.8484	-36	4422.7652	30
10.5	4424.2493	13	4424.3282	-22	4426.5646	-33	4426.4776	48
11.5	4427.5810	20	4427.6546	-20	4429.0424	-14	4428.9518	112
13.5	4430.7356	40	4430.7926	-17	4430.2859	-48	4430.1944	187

J	q1e	c-o	q1f	c-o
1.5	4307.4727	-58	4307.4727	76
2.5	4305.0368	6	4305.0894	4
3.5	4301.6060	5	4301.7327	-3
4.5	4297.1558	0	4297.3978	-20
5.5	4291.6671	23	4292.0694	-22
6.5	4285.1309	31	4285.7384	-37

Table - 3

Observed line positions of 8-6 band of OD

J	p1e	c-o	p1f	c-o	p2e	c-o	p2f	c-o
1.5					4109.2682	-67	4109.1839	-38
2.5	4095.5098	56	4095.5098	-150	4090.1944	-44	4090.1165	-28
3.5	4077.3922	-34	4077.3510	-32	4070.0496	-19	4069.9847	-15
4.5	4058.2385	-14	4058.1717	-15	4048.8750	-11	4048.8265	2
5.5	4038.0512	4	4037.9542	1	4026.6878	139	4026.6878	-114
6.5	4016.8281	22	4016.6977	18	4003.5547	25	4003.5547	23
7.5	3994.5733	40	3994.4073	34	3979.4708	-103	3979.4708	169
8.5	3971.2963	50	3971.0935	37	3954.4234	34	3954.4820	13
9.5	3947.0092	48	3946.7680	35	3928.4666	21	3928.5534	23
10.5	3921.7253	41	3921.4452	27	3901.5962	2	3901.7144	5
11.5	3895.4600	22	3895.1404	9	3873.8223	-27	3873.9716	-14
12.5	3868.2285	-4	3867.8691	-17				
13.5	3840.0461	-41	3839.6543	-129	3815.5978	-98	3815.8117	-72
14.5	3810.9276	-79	3810.4865	-73			3785.4103	-83

J	r1e	c-o	r1f	c-o	r2e	c-o	r2f	c-o
.5					4159.5639	-40	4159.6247	-76
1.5	4171.3723	-110	4171.3723	43	4173.9517	-25	4173.9943	-57
2.5	4183.6705	-156	4183.6705	115	4187.1035	-119	4187.1035	75
3.5	4194.9828	6	4195.0233	-5	4198.9759	-7	4198.9759	-10
4.5	4205.3246	26	4205.3764	10	4209.5867	100	4209.5867	-87
5.5	4214.6568	41	4214.7179	22	4218.9398	184	4218.9398	-164
6.5	4222.9527	49	4223.0200	31	4227.0637	3	4227.0115	44
7.5	4230.1836	59	4230.2562	25	4233.9192	-3	4233.8545	63
8.5	4236.3266	44	4236.3983	26	4239.5295	-30	4239.4554	63
9.5	4241.3551	29	4241.4260	-1	4243.8925	-32	4243.8125	85
10.5	4245.2478	9	4245.3147	-27	4247.0293	-217	4246.9340	50
11.5	4247.9857	-20	4248.0469	-73	4248.8978	-173	4248.8125	21
12.5	4249.5426	26	4249.6051	-136				
13.5			4249.9471	47				

J	q1e	c-o	q1f	c-o
1.5	4134.6541	-111	4134.6541	13
2.5	4132.2037	-30	4132.2521	-29
3.5	4128.7545	-11	4128.8720	-19
4.5	4124.2821	14	4124.5068	-3
5.5	4118.7728	23	4119.1462	-5
6.5	4112.2115	34	4112.7717	37
7.5	4104.5850	77	4105.3808	47

Table - 3

Observed line positions of 9-7 band of OD

J	p1e	c-o	p1f	c-o	p2e	c-o	p2f	c-o
1.5					3935.9036	-30	3935.8234	-2
2.5	3922.5354	91	3922.5354	-97	3917.4035	-21	3917.3269	9
3.5	3904.8609	209	3904.8609	-168	3897.8186	-15	3897.7519	15
4.5	3886.1936	-21	3886.1280	13	3877.1859	-9	3877.1345	22
5.5	3866.4646	5	3866.3728	17	3855.5217	155	3855.5217	-131
6.5	3845.6997	10	3845.5762	18	3832.8951	44	3832.8951	-13
7.5	3823.8998	13	3823.7419	21	3809.3002	-77	3809.3002	117
8.5	3801.0723	15	3800.8777	25	3784.7288	30	3784.7783	2
9.5	3777.2273	17	3776.9956	22	3759.2276	28	3759.3054	2
10.5	3752.3773	17	3752.1069	22	3732.7970	20	3732.9043	-5
11.5	3726.5356	14	3726.2256	19	3705.4450	15	3705.5829	-12
12.5	3699.7157	11			3677.1812	4	3677.3503	-24
13.5	3671.9312	6	3671.5409	1	3648.0118	1	3648.2134	-34
14.5	3643.1960	-3	3642.7645	-11	3617.9470	-15	3618.1801	-41
15.5	3613.5221	-10	3613.0484	-17	3586.9899	-3	3587.2582	-50
16.5	3582.9224	-19	3582.4067	-35	3555.1521	-5	3555.4553	-64
17.5	3551.4084	-29	3550.8493	-43	3522.4399	-14	3522.7777	-73
18.5	3518.9909	-37	3518.3855	-27	3488.8598	-22	3489.2293	-47
19.5	3485.6790	-31	3485.0323	-51	3454.4156	-3	3454.8218	-39
20.5	3451.4822	-8	3450.7904	-28	3419.1141	36	3419.5578	-10
21.5	3416.4126	-5					3383.4383	85
22.5	3380.4721	42	3379.6865	47				

J	r1e	c-o	r1f	c-o	r2e	c-o	r2f	c-o
.5					3984.4332	-13	3984.4901	-55
1.5	3995.9558	-75	3995.9558	63	3998.2295	-78	3998.2583	-9
2.5	4007.7242	-130	4007.7242	116	4010.7750	-118	4010.7750	49
3.5	4018.5098	-170	4018.5098	185	4022.0462	-19	4022.0462	-39
4.5	4028.2725	11	4028.3196	-6	4032.0536	73	4032.0536	-123
5.5	4037.0283	17	4037.0839	-6	4040.7991	143	4040.7991	-208
6.5	4044.7329	27	4044.7941	0	4048.3077	-32	4048.2542	23
7.5	4051.3611	28	4051.4241	8	4054.5394	-24	4054.4748	45
8.5	4056.8862	30	4056.9495	5	4059.5156	-24	4059.4424	65
9.5	4061.2838	41	4061.3450	3	4063.2366	-31	4063.1569	89
10.5	4064.5338	35	4064.5894	-6	4065.6976	-10	4065.6132	154
11.5	4066.6148	22					4066.8312	30

J	q1e	c-o	q1f	c-o
1.5	3960.4719	-60	3960.4719	52
2.5	3957.9964	3	3958.0420	-10
3.5	3954.4232	910	3954.4830	999
4.5	3950.0001	11	3950.2064	-9
5.5	3944.4426	0	3944.7850	-20
6.5	3937.8264	-12	3938.3455	-41
7.5	3930.1340	42		

Table - 3

Observed line positions of 10-8 band of OD

J	p1e	c-o	p1f	c-o	p2e	c-o	p2f	c-o
1.5					3760.2460	102	3760.1684	132
2.5	3747.3000	163	3747.3000	-13	3742.3115	81	3742.2365	113
3.5	3730.0830	228	3730.0830	-129	3723.2726	46	3723.2059	82
4.5	3711.8573	20	3711.7977	19	3703.1643	3	3703.1104	55
5.5	3692.5705	-15	3692.4847	-40	3682.0097	34	3682.0097	-263
6.5	3672.2347	-21	3672.1178	-60	3659.8497	-11	3659.8497	-82
7.5	3650.8557	-34	3650.7054	-95	3636.7086	-167	3636.7086	17
8.5	3628.4382	-39	3628.2520	-117	3612.5994	-396	3612.5994	63
9.5	3604.9900	-25	3604.7674	-131	3587.4787	-132	3587.5456	-52
10.5	3580.5228	-4	3580.2615	-124	3561.4324	-125	3561.5275	-32
11.5	3555.0475	27	3554.7463	-98	3534.4404	-84	3534.5662	-1
12.5	3528.5751	76	3528.2343	-57	3506.5137	-43	3506.6689	40
13.5	3501.1189	122	3500.7369	1	3477.6556	31	3477.8432	78
14.5	3472.6888	170	3472.2814	-85	3447.8754	102	3448.0947	106
15.5	3443.2970	195	3442.8307	155	3417.1715	231	3417.4290	111
16.5	3412.9538	178	3412.4433	226	3385.5625	269	3385.8535	51
17.5	3381.6661	121	3381.1133	261	3353.0554	171	3353.3405	222
18.5	3349.4465	-49	3348.8500	228			3319.9918	-387
19.5	3316.2997	-341	3315.6563	139				
20.5			3281.5455	-111				
21.5			3246.5186	-530				

J	r1e	c-o	r1f	c-o	r2e	c-o	r2f	c-o
.5					3806.9934	139	3807.0483	78
1.5	3818.2435	18	3818.2435	137	3820.1881	-93	3820.1881	233
2.5	3829.4589	-49	3829.4589	156	3832.0957	-35	3832.0957	118
3.5	3839.6545	45	3839.6545	334	3842.7350	9	3842.7350	-4
4.5	3848.8424	-4	3848.8790	-15	3852.1023	26	3852.1023	-139
5.5	3856.9795	0	3857.0284	-88	3860.2070	-83	3860.1760	-67
6.5	3864.0477	-11	3864.1011	-127	3867.0363	-182	3866.9810	-23
7.5	3870.0183	-10	3870.0739	-159	3872.5850	-199	3872.5202	-16
8.5	3874.8672	-9	3874.9213	-180	3876.8624	-219	3876.7875	19
9.5	3878.5699	-2	3878.6169	-165	3879.8638	-207	3879.7843	58
10.5	3881.1137	-96	3881.1137	130	3881.5862	-159	3881.5862	-688
11.5	3882.4566	-83			3882.0273	-101	3882.1811	-999

Table - 3

Observed line positions of 5-2 band of OD

J	p1e	c-o	p1f	c-o	p2e	c-o	p2f	c-o
2.5	7063.8761	119	7063.8761	-155			7056.9427	-72
3.5	7042.6071	-34	7042.5512	-22	7033.0551	12	7032.9824	15
4.5	7019.7730	-46	7019.6788	8	7007.4874	218		
5.5	6995.3639	6	6995.2397	-34	6980.4183	101	6980.4183	-102
6.5	6969.3877	-15	6969.2162	-17	6951.8571	-82	6951.8571	40
7.5	6941.8405	-35	6941.6195	-3				
8.5	6912.7299	-22	6912.4632	-12	6890.3716	-826	6890.3716	27
9.5	6882.0758	-16	6881.7560	29	6857.3463	-31	6857.4690	-11
10.5	6849.8933	10	6849.5279	6			6823.1459	-92
11.5	6816.2059	20	6815.7886	18			6787.3950	-20

Table - 3

Observed line positions of 6-3 band of OD

J	p1e	c-o	p1f	c-o	p2e	c-o	p2f	c-o
1.5					6821.2248	-9		
2.5	6806.0829	59	6806.0829	-199	6799.5024	20	6799.4128	41
3.5	6785.3103	-34	6785.2593	-40	6776.1481	23	6776.0792	-18
4.5	6762.9874	10	6762.9040	0	6751.2148	8	6751.1655	-13
5.5	6739.1166	-3	6738.9938	-1	6724.7334	111	6724.7334	-134
6.5	6713.6848	-14	6713.5178	8	6696.7753	-37	6696.7753	27
7.5	6686.6934	-13	6686.4806	16	6667.3427	-198	6667.3427	205
8.5	6658.1510	3	6657.8935	7	6636.4179	2	6636.4967	-20
9.5	6628.0729	17	6627.7675	13	6604.0704	28	6604.1888	-10
10.5	6596.4783	0	6596.1247	-21	6570.3061	-46	6570.4537	16
11.5	6563.3754	49	6562.9748	-12			6535.3101	-7
12.5	6528.7986	7	6528.3443	-38			6498.7639	-23
13.5	6492.7531	11						

Table - 3

Observed line positions of 7-4 band of OD

J	p1e	c-o	p1f	c-o	p2e	c-o	p2f	c-o
1.5					6563.6020	68		
2.5	6548.8036	137	6548.8036	-105	6542.4862	21	6542.3961	49
3.5	6528.5200	32	6528.4731	13	6519.7255	45	6519.6514	36
4.5	6506.7024	-3	6506.6214	2	6495.3824	24	6495.3257	35
5.5	6483.3375	-6	6483.2214	-22	6469.4788	170	6469.4788	-135
6.5	6458.4204	-2	6458.2642	-31	6442.0962	12	6442.0962	2
7.5	6431.9525	4	6431.7500	-9	6413.2296	-134	6413.2296	183
8.5	6403.9431	-8	6403.6974	-60	6382.8719	4	6382.9419	-23
9.5	6374.3982	14	6374.1045	-43	6351.0841	-17	6351.1910	-40
10.5	6343.3403	-3	6342.9948	-44	6317.8627	-28	6318.0057	-23
11.5	6310.7779	12	6310.3790	-5	6283.2217	-46	6283.4030	-22
12.5	6276.7335	6	6276.2869	-52	6247.1683	-30	6247.3926	-21
13.5	6241.2208	14	6240.7198	-24				
14.5	6204.2628	-19	6203.7031	-3	6170.8737	57		
15.5			6165.2547	1				
16.5			6125.3882	21				

J	r1e	c-o	r1f	c-o	r2e	c-o	r2f	c-o
.5					6616.5470	29	6616.5470	596
1.5	6628.2889	-85	6628.2889	76	6630.6540	-147	6630.6540	201
2.5	6639.8994	-157	6639.8994	117	6642.8997	-66	6642.8997	52
3.5	6650.0625	-194	6650.0625	184	6653.3040	41	6653.3040	-57
4.5	6658.7275	21	6658.7738	16	6661.8780	139	6661.8780	-150
5.5	6665.9091	7	6665.9647	-45	6668.6369	203	6668.6369	-240
6.5	6671.5523	-31	6671.6076	-73				
7.5	6675.6063	84	6675.6679	-50				
8.5	6678.1059	-288	6678.1059	125				
9.5	6678.9219	-118	6678.9219	191				

Table - 3

Observed line positions of 8-5 band of OD

J	p1e	c-o	p1f	c-o	p2e	c-o	p2f	c-o
1.5							6305.4680	-30
2.5	6291.1311	59	6291.1311	-166	6285.0262	-57	6284.9405	-54
3.5	6271.3212	-29	6271.2755	-29	6262.8444	-20	6262.7705	-27
4.5	6249.9791	-31	6249.9028	-24	6239.0697	-27	6239.0134	-33
5.5	6227.0941	-1	6226.9832	-3	6213.7179	176	6213.7179	-159
6.5	6202.6620	19	6202.5110	18	6186.8777	39	6186.8777	-19
7.5	6176.6817	33	6176.4876	31	6158.5424	-111	6158.5424	142
8.5	6149.1589	35	6148.9200	23	6128.7000	48	6128.7639	4
9.5	6120.1017	40	6119.8141	36	6097.4197	-7	6097.5123	23
10.5	6089.5245	26	6089.1869	28	6064.6869	0	6064.8195	9
11.5	6057.4378	29	6057.0513	14	6030.5244	-38	6030.6984	-45
12.5	6023.8644	-25	6023.4243	-22	5994.9384	-70	5995.1512	-55
13.5	5988.8113	-50	5988.3190	-54	5957.9384	-86	5958.1922	-56
14.5	5952.2980	-82	5951.7517	-85	5919.5321	-53	5919.7872	402
15.5	5914.3425	-143	5913.7353	-83				
16.5	5874.9508	-133	5874.3456	-648				
17.5			5833.5855	-999				

J	r1e	c-o	r1f	c-o	r2e	c-o	r2f	c-o
.5					6356.7330	-18	6356.7330	516
1.5	6368.1951	-107	6368.1951	41	6370.2576	-166	6370.2576	157
2.5	6379.2904	-138	6379.2904	113	6381.9315	-95	6381.9315	8
3.5	6388.9300	-169	6388.9300	176	6391.7682	16	6391.7682	-87
4.5	6397.0640	20	6397.1061	15	6399.7767	131	6399.7767	-154
5.5	6403.6974	59	6403.7530	-42	6405.9932	-12	6405.9932	-443
6.5	6408.7839	72	6408.8351	13	6410.3563	320	6410.3563	-216
7.5	6412.2966	6	6412.3396	-8				
8.5	6414.2066	-143	6414.2066	193				
9.5	6414.4595	-98	6414.4595	125				
10.5	6413.0547	-82	6412.9934	602				
11.5	6409.9652	-30						
12.5	6405.1741	49						

Table - 3

Observed line positions of 9-6 band of OD

J	p1e	c-o	p1f	c-o	p2e	c-o	p2f	c-o
1.5					6046.0067	42	6045.9224	22
2.5	6031.9802	85	6031.9802	-126	6026.0477	32	6025.9598	57
3.5	6012.6282	-14	6012.5826	10	6004.4285	21	6004.3499	37
4.5	5991.7384	-7	5991.6663	-4	5981.1945	7	5981.1310	24
5.5	5969.3064	-5	5969.1997	-1	5956.3613	232	5956.3613	-173
6.5	5945.3228	2	5945.1782	-6	5930.0233	84	5930.0233	-62
7.5	5919.7869	1	5919.6012	-23	5902.1702	-71	5902.1702	79
8.5	5892.7010	5	5892.4676	1	5872.8005	-9	5872.8488	-14
9.5	5864.0731	11	5863.7945	-17	5841.9569	5	5842.0428	-22
10.5	5833.9132	23	5833.5854	-8	5809.6522	-15	5809.7730	-20
11.5	5802.2365	10	5801.8577	-20	5775.8935	-27	5776.0519	-19
12.5	5769.0502	28	5768.6200	-5	5740.6923	-45	5740.8888	-15
13.5	5734.3748	11	5733.8913	-17	5704.0470	40		
14.5	5698.2187	3	5697.6822	-31			5666.2706	30
15.5	5660.5954	0	5659.9869	147			5626.8305	92
16.5	5621.5208	-31	5620.8675	19			5585.9911	70

J	r1e	c-o	r1f	c-o	r2e	c-o	r2f	c-o
1.5	6106.6074	-80	6106.6074	53	6108.3417	-95	6108.3417	171
2.5	6117.1673	-120	6117.1673	103	6119.4153	-25	6119.4153	23
3.5	6126.2520	-143	6126.2520	159	6128.6510	69	6128.6510	-86
4.5	6133.8385	-186	6133.8385	170	6136.0555	156	6136.0555	-175
5.5	6139.8883	-175	6139.8883	200	6141.6617	-9	6141.6160	-22
6.5	6144.3756	-177	6144.3756	180	6145.4389	-23	6145.3784	15
7.5	6147.4143	-999	6147.4143	-999	6147.4143	-66	6147.3461	-4

J	q1e	c-o	q1f	c-o
1.5	6071.1217	-54	6071.1217	65
2.5	6067.4833	-446	6067.4833	18
3.5	6062.2558	-18	6062.3634	23

Table - 3

Observed line positions of 10-7 band of OD

J	p1e	c-o	p1f	c-o	p2e	c-o	p2f	c-o
1.5					5783.6796	-23	5783.5899	57
2.5	5770.0868	124	5770.0868	-71	5764.2796	-19	5764.1920	45
3.5	5751.1509	266	5751.1509	-136	5743.1963	-11	5743.1176	41
4.5	5730.7163	8	5730.6464	27	5720.4757	-36	5720.4093	38
5.5	5708.7015	17	5708.6017	-3	5696.1456	10	5696.1083	0
6.5	5685.1259	8	5684.9880	-18	5670.2470	39	5670.2470	-88
7.5	5659.9869	-20	5659.8046	-36	5642.8241	-129	5642.8241	37
8.5	5633.2776	13	5633.0549	-60	5613.8774	-295	5613.8774	199
9.5	5604.9980	168	5604.7397	-38	5583.3933	-153	5583.4641	-17
10.5	5575.1994	12	5574.8803	-94	5551.4312	-166	5551.5370	-11
11.5	5543.8440	20	5543.4743	-101	5517.9842	-155	5518.1285	-3
12.5	5510.9601	17	5510.5383	-113	5483.0661	-162	5483.2495	-12
13.5	5476.5554	34	5476.0798	-92	5446.6803	-139	5446.9038	0
14.5	5440.6443	36	5440.1136	-74	5408.8354	-100	5409.0985	35
15.5	5403.2340	52	5402.6476	-31	5369.5353	-17	5369.8413	74
16.5	5364.3392	33	5363.6944	11	5328.7937	28	5329.1448	44
17.5	5323.9645	20	5323.2551	135			5286.9978	103
18.5			5281.3480	240				

J	r1e	c-o	r1f	c-o	r2e	c-o	r2f	c-o
1.5	5842.2469	-29	5842.2469	.85	5843.6158	-160		
2.5	5852.2442	-74	5852.2442	112	5854.0584	-82		
3.5	5860.7451	-143	5860.7451	100	5862.6542	-4		
4.5	5867.7142	-144	5867.7142	128	5869.4066	57		
5.5	5873.1300	-163	5873.1300	102	5874.2968	353		
6.5	5876.9551	-143	5876.9551	76	5877.3741	463		
7.5	5879.1602	-104	5879.1602	28	5878.6041	802		
8.5	5879.7179	-69	5879.7179	-60	5878.0779	506		
9.5	5878.6041	-71						

Table 4 Molecular Parameters for the $X^2\Pi_u$ State of OD

<i>v</i>	0	1	2	3
T_e	0.0	2632.0597(2)	5175.8296(2)	7632.2061(2)
A	-139.0255(10)	-139.2206(11)	-139.4174(10)	-139.6093(10)
B	9.883084(38)	9.607418(35)	9.334654(35)	9.064254(34)
$D \times 10^3$	.5386(21)	.5309(18)	.5235(19)	.5159(18)
$H \times 10^6$	[.190]	[.1943]	[.189]	[.168]
$A_D \times 10^3$	-.137(52)	-.94(52)	-.056(51)	-.027(50)
p	.12295(17)	.11919(17)	.11471(17)	.11069(17)
$p_D \times 10^4$	[-.0115]	[-.0139]	[-.0479]	[-.0538]
$q \times 10^1$	-.10948(31)	-.106041(30)	-.102426(31)	-.09907(31)
$q_D \times 10^4$	[.219]	[.224]	[.229]	[.248]
$q_H \times 10^9$	[-.152]	[-.146]	[-.146]	[-.146]
$L \times 10^{12}$	[-.706]	[-.64]	[-.64]	[-.64]
$A_H \times 10^5$	[.214]	[.121]	[.121]	[.121]

<i>v</i>	4	5	6	7
T_e	10000.1874(2)	12285.2920(3)	14482.6480(3)	16593.8288(3)
A	-139.7977(10)	-139.9765(10)	-140.0140(10)	-140.0291(10)
B	8.795839(35)	8.528654(35)	8.261966(36)	7.994678(38)
$D \times 10^3$	.5099(19)	.5046(20)	.5004(21)	.4965(23)
$H \times 10^6$	[.163]	[.154]	[.1413]	[.118]
$A_D \times 10^3$	.11(50)	.45(49)	.078(49)	.141(49)
p	.10616(17)	.10167(17)	.0972(17)	.09158(17)
$p_D \times 10^4$	[-.0798]	[-.0173]	[-.0950]	[-.153]
$q \times 10^1$	-.0954(31)	-.09151(33)	-.08795(33)	-.08333(35)
$q_D \times 10^4$	[.252]	[.247]	[.258]	[.228]
$q_H \times 10^9$	[-.146]	[-.146]	[-.146]	[-.146]
$L \times 10^{12}$	[-.64]	[-.64]	[-.64]	[-.64]
$A_H \times 10^5$	[.121]	[.121]	[.121]	[.121]

^a All values are given in reciprocal centimeters, and the error quoted is one standard deviation in the last decimal place. The standard deviation is 0.007 cm^{-1} for reproducing individual spectral lines. Bracketed quantities are held constant during the fitting process.

Table 4 Molecular Parameters for the $X^2\Pi_1$ State of OD

<i>v</i>	8	9	10
T_e	18618.3419(3)	20555.3227(3)	22403.3649(3)
A	-140.4037(10)	-140.4849(10)	-140.5066(10)
B	7.726449(40)	7.454621(42)	7.178354(43)
$D \times 10^3$	.4986(24)	.4959(26)	.4968(27)
$H \times 10^6$	[.173]	[.848]	[.400]
$A_D \times 10^3$	.186(48)	.253(48)	.360(47)
p	.08712(18)	.08136(18)	.07580(18)
$p_D \times 10^4$	[-.161]	[-.173]	[-.175]
$q \times 10^1$	-.07956(37)	-.07511(38)	-.06783(39)
$q_D \times 10^4$	[.242]	[.230]	[.112]
$q_H \times 10^9$	[-.146]	[-.146]	[-.146]
$L \times 10^{12}$	[-.64]	[-.64]	[-.64]
$A_H \times 10^5$	[.121]	[.121]	[.121]

^a All values are given in reciprocal centimeters, and the error quoted is one standard deviation in the last decimal place. The standard deviation is 0.007 cm^{-1} for reproducing individual spectral lines. Bracketed quantities are held constant during the fitting process.